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Optimization of TCS for MFS on SmallSat

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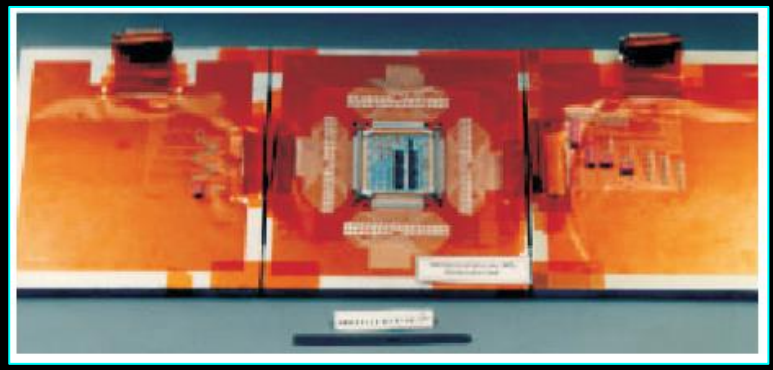
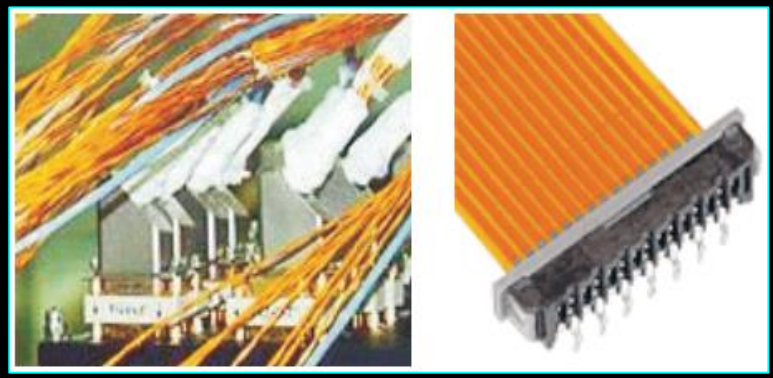
AGENDA

- Background
- System Design
- Optimization Study 1
- Optimization Study 2
- Conclusions
- Further Work

BACKGROUND

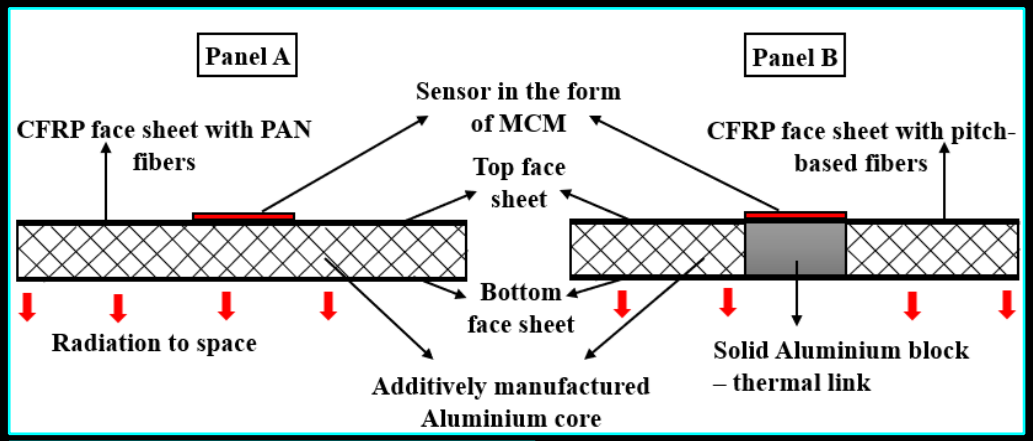
- MFS integrates various subsystems into main composite panel structure
- Reduction of mass, volume, and cost by replacing chassis, cables, and connectors with flex-interconnect systems
- MCM mounted on the top face sheet
- Thermal dissipation management: HiK composite sandwich panel and using thermal links between face sheets.
- The work focuses on optimizing those thermal links by
  - Varying the geometry of core fill
  - Changing the type of thermal link
  - Exploring thermo-optical properties of bottom face sheet

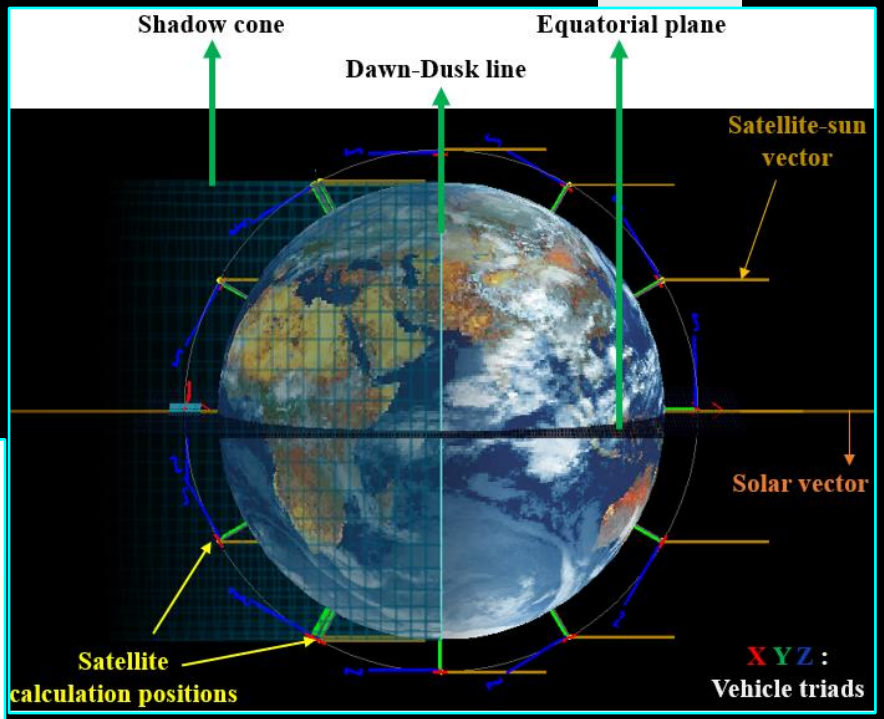


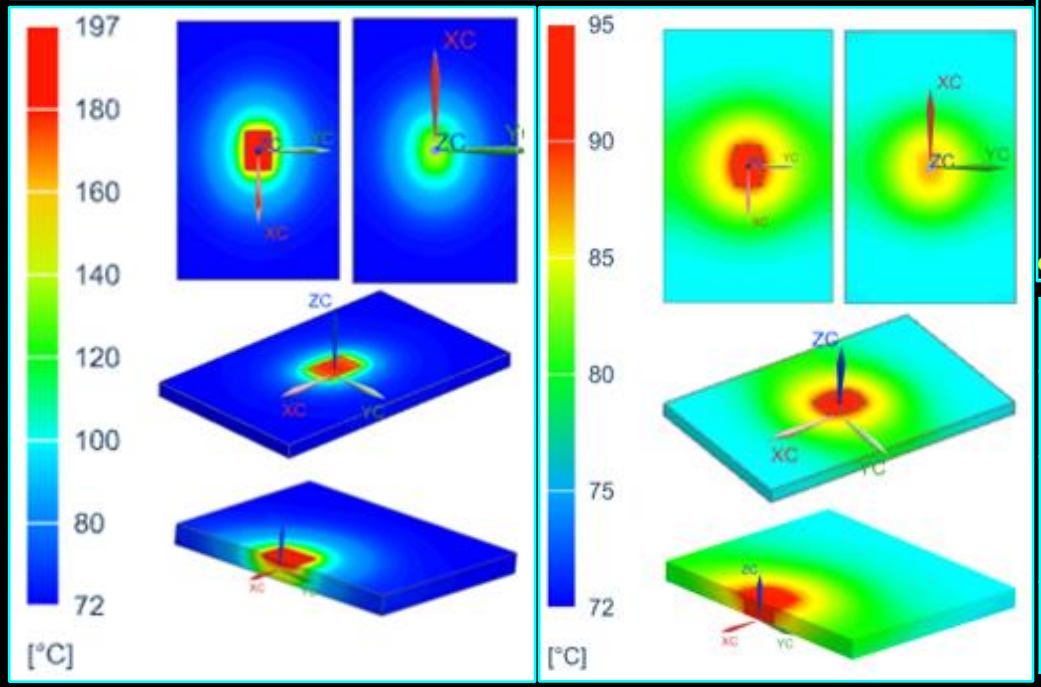


Aglietti, Guglielmo S., Christoph W. Schwingshackl, and Samuel C. Roberts. "Multifunctional structure technologies for satellite applications." Shock and Vibration Digest 39, no. 5 (2007): 381-394.

SYSTEM DESIGN







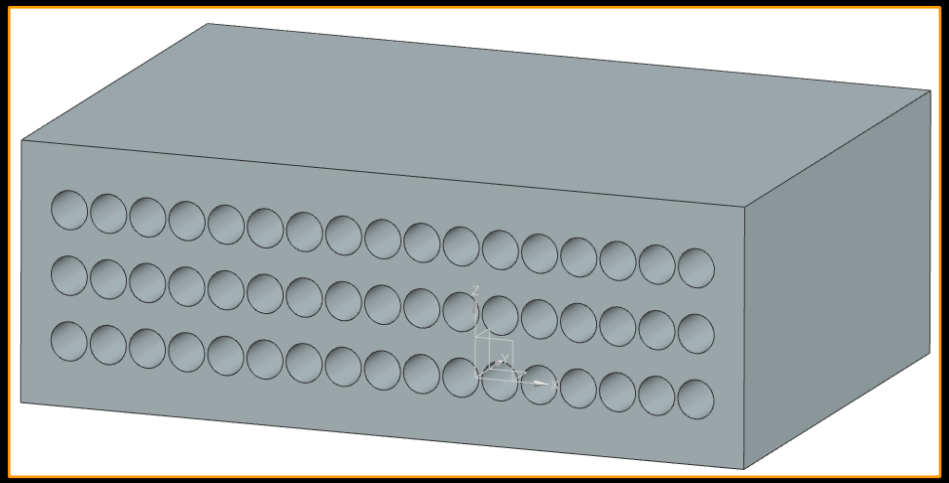
Variables	Panel	Values
Design temperature limit		100°C
Temperature	A	197°C
	B	95°C
Al block - Mass penalty	B	133.4 g

Perfetto, S., M. Schubert, D. Mayer, A. Dafnis, and H. Atzrodt. "DEVELOPMENT AND DESIGN OF MULTIFUNCTIONAL COMPOSITE STRUCTURES FOR SATELLITE APPLICATIONS."

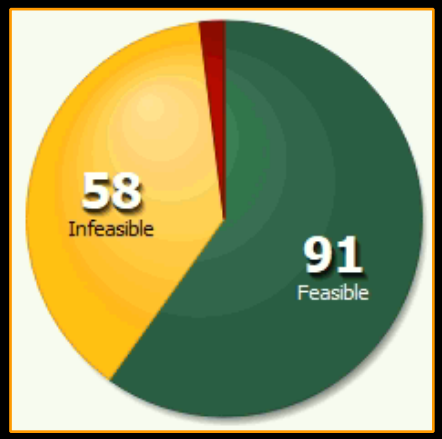
OPTIMIZATION STUDY 1

- Volume extraction from solid block with through-thickness holes
- Optimization using Hierarchical Evolutionary Engineering Design System (HEEDS) Multi-disciplinary Design Optimization (MDO)
- SHERPA (Simultaneous Hybrid Exploration that is Robust, Progressive, and Adaptive) search algorithm:
  efficient and robust

Objective	
Minimize mass of solid Al block	
Assigned Variable Range in HEEDS	
Number of holes	3: 1: 10
Hole diameter	2: 0.007: 3
Assigned Constraints	
Temperature	< 96.4 ℃
Mass of Al block	< 128 g

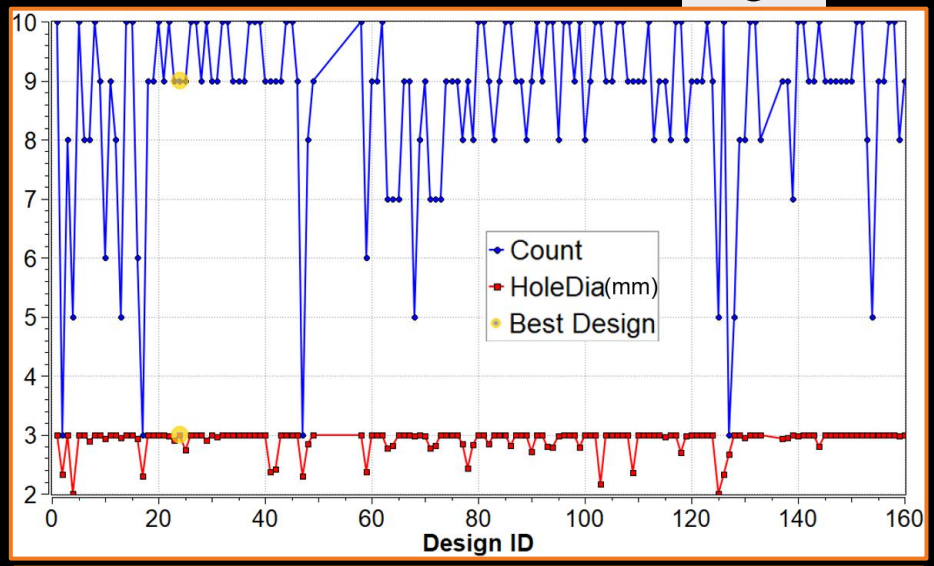


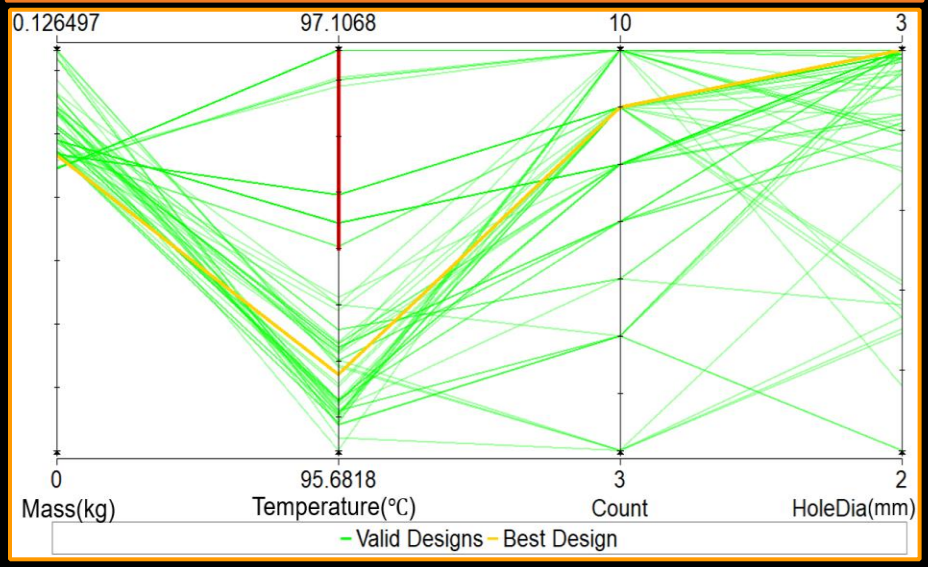
STUDY 1- RESULTS



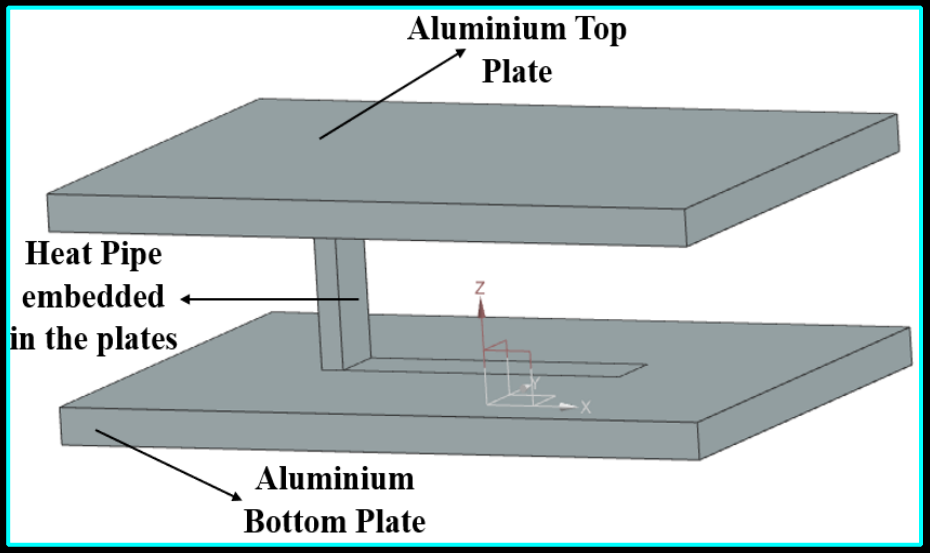
Optimized	Value
Mass	93.3 g
Temperature	96 °C
Count	9
Hole diameter	3 mm

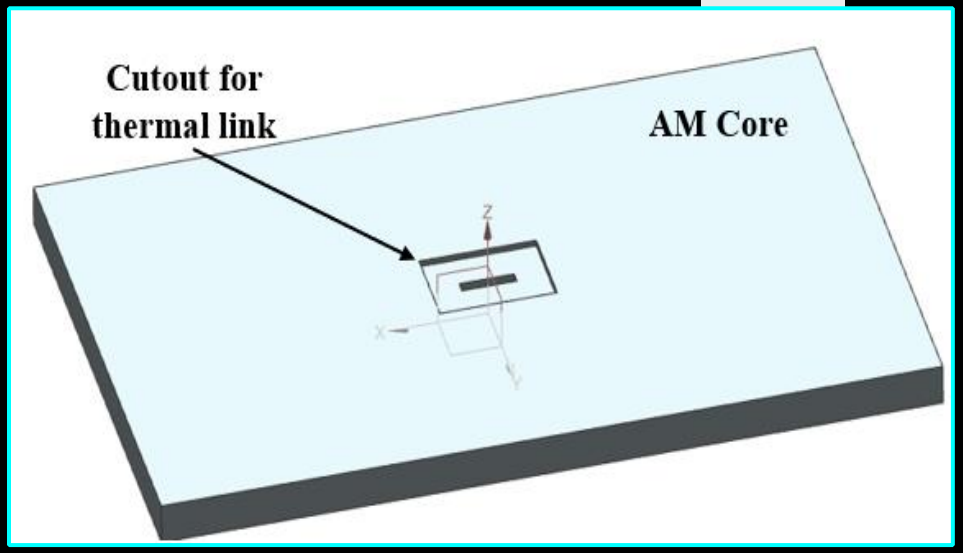
30 % mass reduction achieved

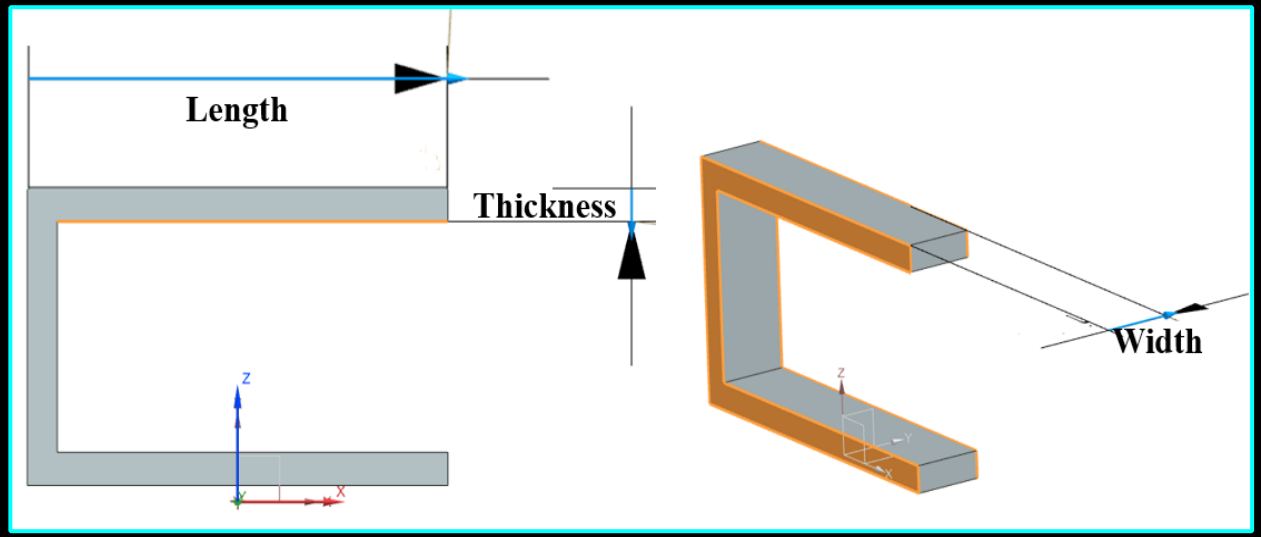




OPTIMIZATION STUDY 2







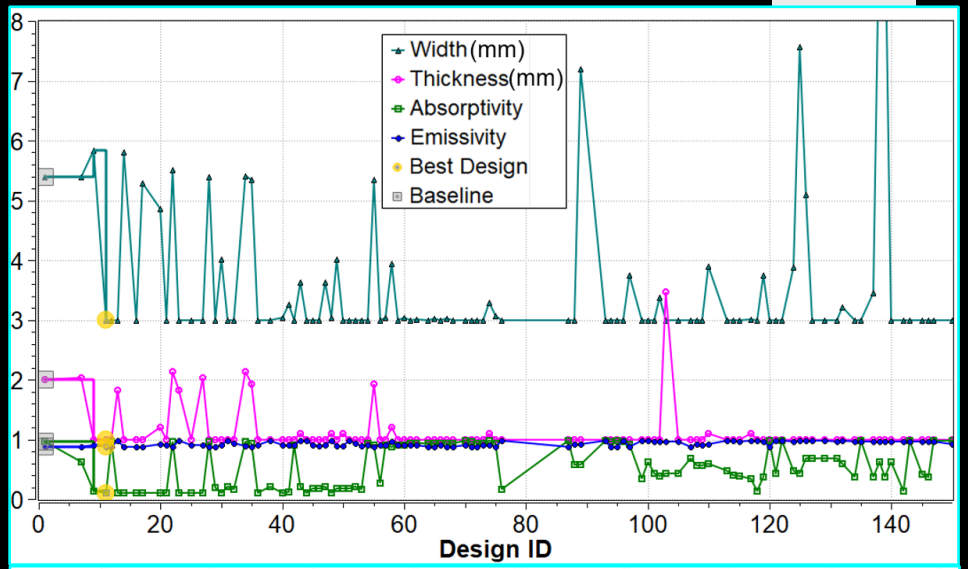
STUDY 2 - PARAMETERIZATION

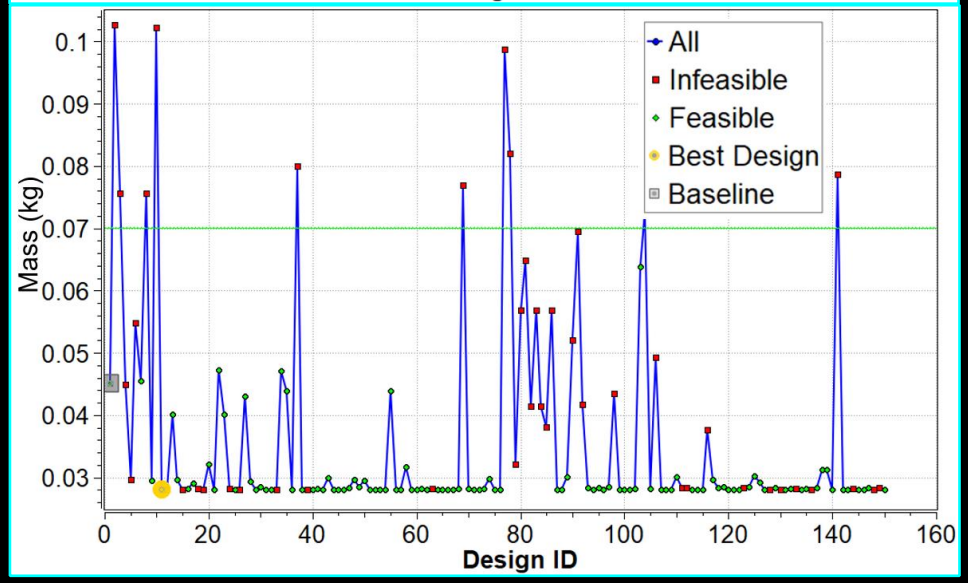
Baseline Parameters			Assigned Variable Range in HEEDS
Variables			
Heat pipe (HP) dimensions (mm)	Length	Total HP length - 70 ; Length of cut-out within each Al plate- 28	26: 0.5: 34
	Width	5.39	3: 0.01: 10
	Thickness	2	1: 0.1: 5
Aluminum plates	Height		Variables as a function of heat pipe dimensions
Cut-out in Al plates	Length1, Width1, Thickness 1		
AM core section surrounding thermal link	Dimension1, Dimension2, Dimension3		
Absorptivity		0.96	0.1: 0.01: 0.98
Emissivity		0.88	0.1: 0.01: 0.98
Baseline resultant values			
Temperature			97.11 °C
Mass of heat pipe and Al plates			89 g
Assigned Constraints			
Temperature			< 98 °C
Mass of heat pipe and Al plates			<70 g

STUDY 2 - RESULTS

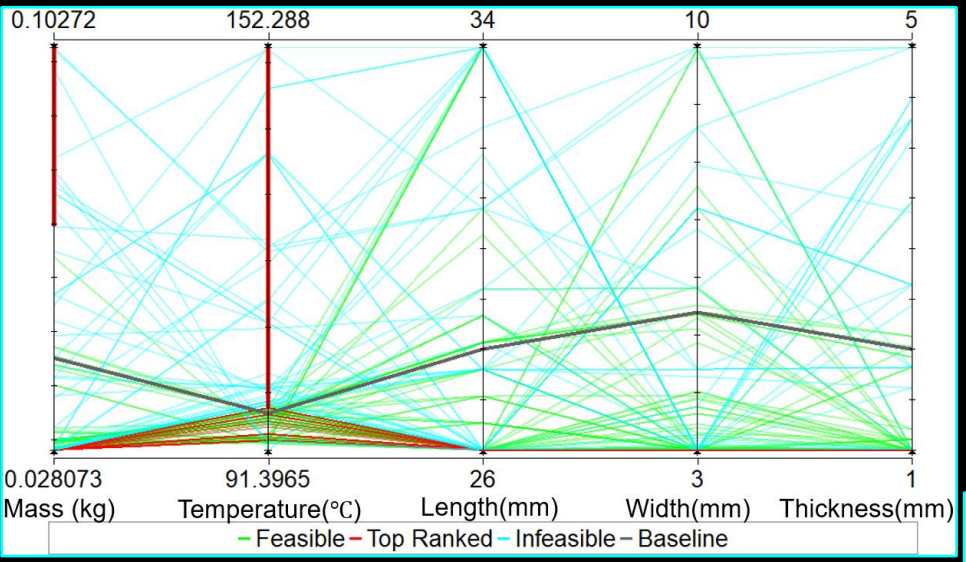
Optimized	Value
Mass	28.07 g
Temperature	92.8 °C
Heat pipe total length	68 mm
Aluminium plate	2 mm
Absorptivity	0.1
Emissivity	0.98

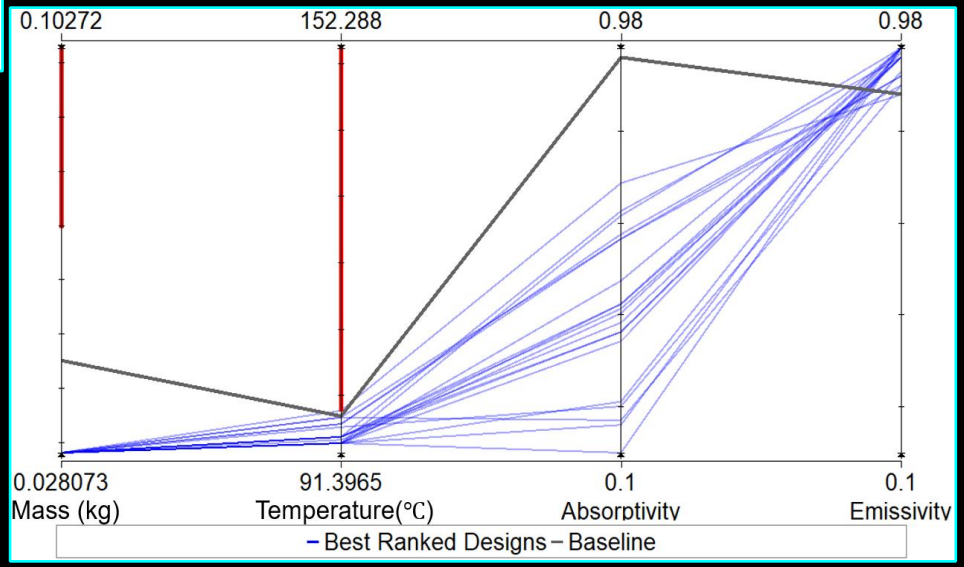
78.9% Mass Reduction Achieved





STUDY 2 - RESULTS



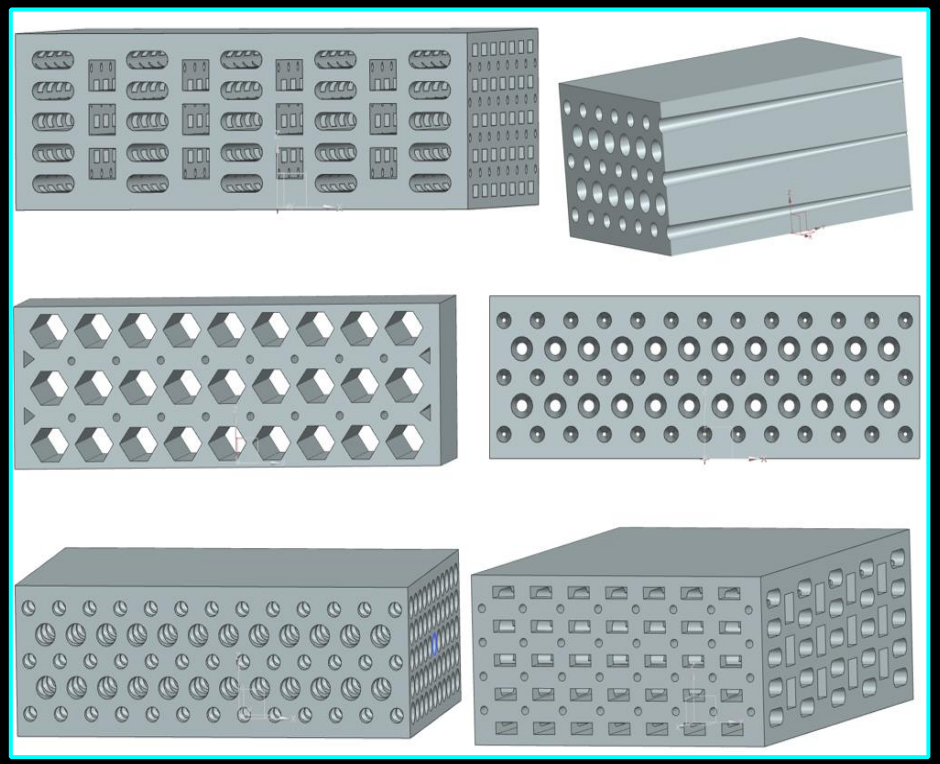


CONCLUSIONS

- HEEDS expedites the design optimization process
- Prerequisite - CAD robustness through parameterization
- Optimization of TCS of MFS - identify least mass with similar thermal performance
- 30% reduction in mass compared to a solid block
  - varying its geometry
- 78.9% reduction in mass when compared to solid block
  - replacing it with heat pipe embedded in the Al plates
  - exploring thermo-optical properties
- Choose best design by data visualization and comparison based on
  - manufacturing ability
  - time
  - cost

FURTHER WORK

- Exploring parameterization for optimization which might result in unconventional geometries
- Varying thermal conductivity of the structural components
- Optimization of location of multiple MCM dissipating different amounts of heat



THANK YOU!